Forage Quality/Nutritive Value

Many attempts have been made to define forage quality in terms of leafiness, stem thickness, color, smell, or by content of protein, fiber, or lignin. Chemical composition of forages is a useful, but imperfect, measure of quality. With stored forage, factors such as leafiness, lack of dust, color, and lack of weeds may also come into play in evaluation of forage. However, while these laboratory and visual approaches are helpful, they actually are indicators of nutritive value (the potential of a forage) rather than forage quality. Ultimately, forage quality is defined in terms of animal performance such as daily gain, reproduction, or milk production.

Palatability

Selectivity normally results from livestock showing preference for the most palatable plants or plant parts, though behavioral factors may have an influence. Generally, high quality forages are highly palatable and vice-versa, but not always. Animal selection of one forage species over another depends on smell, touch, and taste. Palatability may be affected by texture, aroma, succulence, hairiness, leafiness, fertilization, dung pads, urine patches, sugar content, or other factor.

When animals are restricted to a less palatable species, their performance may be quite satisfactory if forage nutritive value is high and intake is not reduced. For example, grazing animals will select oats in preference to rye even though they will perform well when restricted to rye pasture.

In cafeteria-style plots, horses consistently selected and grazed oats (being grazed) o annual ryegrass as compared to rye (right), wheat, or triticale. Athens, Georgia.

Annual ryegrass is even more palatable than oats to horses. Thus, palatability alone can be a misleading indicator of nutritive value. In addition, palatability of a forage species may change during the growing season.

Forage Digestion by Animals

Ruminant animals (i.e., cattle, sheep, goats, deer, camels, water buffalo, bison, llamas, and alpaca) have an enlarged three- or four-compartmented stomach that permits them to digest large amounts of forage with a high fiber content. This unique and valuable characteristic enables these animals to utilize materials that cannot be efficiently utilized by non-ruminants. Forage consumed by ruminants moves from the esophagus into the rumen and reticulum, then is regurgitated and chewed before being digested by rumen microflora (**Figure 17.1**).

Volatile fatty acids from the digestion process are absorbed through the rumen wall and utilized by the animal. Microbes and undigested material pass into the omasum where water is absorbed. Then the microbes are degraded in the abomasum (true stomach) and the products are absorbed in the small intestine for use by the animal. Starch and sugars are absorbed in the small intestine. Digestibility (the proportion of the forage consumed in passage through the alimentary tract) varies, depending on the type of material consumed by the animal. Immature leafy grasses or white clover may be 80 to 90 percent digestible, but mature stemmy material is often below 50 percent.

Certain non-ruminant animals such as horses and mules have a functional cecum and colon where microbes digest fiber (**Figure 17.2**). However, the cecum (the fermentation vat) and colon follow the small intestine, and the total stomach capacity is much smaller than for ruminants. Hence, microbial activity is low in the horse. Horses break down only about 30 percent of the fiber in forage, whereas ruminants utilize 60 to 70 percent. Horses cannot digest as much low-quality material as ruminants, thus higher quality forage must be fed for good performance.

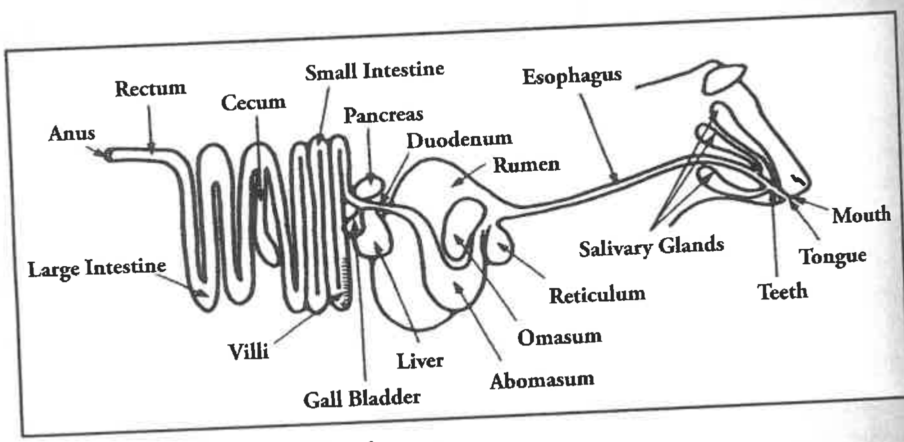


Figure 17.1 Digestive system of a cow.

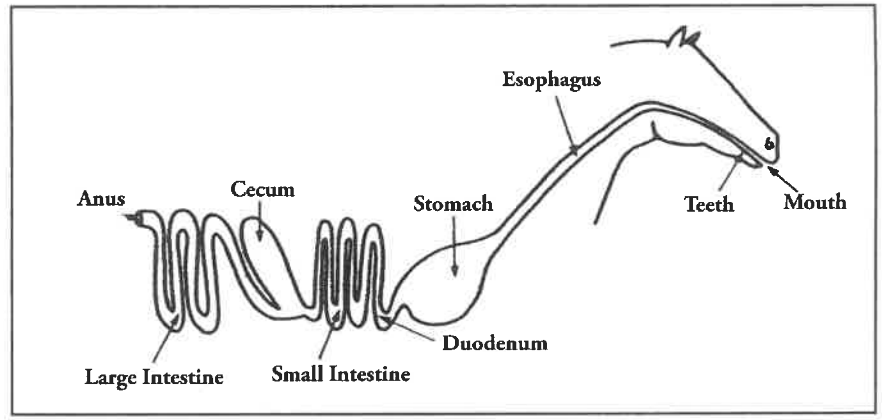


Figure 17.2 Digestive system of a horse.

Forage Composition

Leafy, growing forage plants usually contain 70 to 90 percent water, so it is preferable to express forage yields and chemical analyses on a dry matter basis. Forage constituents (see **Appendix A.28**) can be divided into two main categories: 1) those present as cell contents or the non-structural part of the plant tissue (mainly protein, sugar, and starch) and 2) those that make up the structural components of cell walls (primarily cellulose, hemicellulose, and lignin).

Cell contents are almost completely digested, while cell walls vary in digestibility due to many factors, including forage species, age, and temperature. In addition, minerals, vitamins, and anti-quality factors such as tannins, nitrates, alkaloids, cyanoglycosides, estrogens, and mycotoxins influence animal performance, depending on the plant species and environmental conditions.

Protein

Digestible proteins are located in the cell cytoplasm (cell contents), and relatively indigestible proteins are found in the chloroplasts (structures located within the cytoplasm), where they make up about 40 percent of the total protein. Cell walls tend to retain large protein molecules, often making them unavailable to the animal during digestion. Chemical analyses for proteins are most commonly expressed as crude protein (CP), indicating some of the proteins may be unavailable for animal utilization (see **Appendix A.41**).

The portion of CP that is unavailable varies with crop species, stage of maturity at harvest, and other factors. In plants such as bermudagrass and bahiagrass, which have highly lignified cell walls, much of the CP may be unavailable to the animal. However, protein quality is not of great importance for beef cows on pasture since all amino acids can be synthesized by rumen microorganisms.

Young, leafy grasses and legumes are normally high in protein and usually meet the protein needs of grazing animals. Perennial cool season grasses generally contain less protein than legumes, but have adequate amounts for most types and classes of animals. Winter annual pastures such as small grains and annual ryegrass contain high levels of crude protein, yet growing stocker cattle gain faster when supplemented with rumen bypass protein feeds such as fish meal or certain grain components. The reason is that a large portion of the digestible nitrogen in the forage is soluble and is quickly converted to ammonia in the rumen and lost.

Well-fertilized warm season pasture grasses or hay cut at early stages of maturity generally contain adequate protein for beef cows. However, insufficient protein can be a problem in warm season grasses that received inadequate nitrogen fertilizer, and especially on frosted pasture during winter or in hay cut at advanced stages of maturity.

Digestible Energy

Carbohydrates are chemical compounds composed of carbon, hydrogen, and oxygen. They are extremely important nutritionally because they are the main source of energy in food. Non-structural carbohydrates in forages are readily digested by animals of all types. However, ruminant animals have the unique ability to digest some of the structural carbohydrates located in the cell walls of plants.

Cellulose and hemicellulose are structural carbohydrates that may be digested by bacterial action in the rumen, but digestion is sharply reduced as lignin content increases. Lignin, indigestible in ruminant and non-ruminant animals, is low in legumes such as white clover and birdsfoot trefoil or immature small grains and ryegrass. Alfalfa, a high-quality legume at immature growth stages, declines rapidly in digestibility as stem lignin content increases with maturity. Warm season perennial grasses such as bermudagrass and switchgrass develop lignin rapidly as they mature, which reduces their digestibility. Highly lignified forages remain in the rumen for long periods of time because of their slow rate of digestion, thus decreasing dry matter intake and therefore markedly reducing animal performance.

Digestible energy is generally the most limiting nutritive factor affecting forage intake and animal performance. Animal production falls off rapidly, and weight loss may result when highly lignified, overly-mature warm season perennial grasses are consumed. Forage utilization and animal performance are dependent on digestibility and voluntary intake of the forage. Generally, there is a high correlation between digestibility and forage intake and between intake and animal performance.

Factors Affecting Nutritive Value

1. Plant species

Cool season grasses are generally more digestible than warm season grasses. For instance, tall fescue forage is usually more digestible than bermudagrass. Furthermore, cool season annual species (annual ryegrass, oats, wheat, and rye) are more digestible than cool season perennial grasses (orchardgrass, tall fescue, or Kentucky bluegrass) at the same stage of maturity. There are also differences among species having similar seasonal distribution of growth, as evidenced by warm season grasses such as dallisgrass and johnsongrass, which are more digestible than bahiagrass, bermudagrass, or carpetgrass at the same stage of maturity.

With some forages, breeding has resulted in significant improvements in digestibility. Tifton 85 bermudagrass is about 11 percent more digestible than Coastal bermudagrass (and higher yielding) and thus can greatly increase animal gains (see **Table 28.1**). Brown midrib (BMR) corn and sorghum varieties have less lignin and may be 10 to 30 percent more digestible (though some BMR varieties produce as much as 15 to 20 percent less dry matter and may lodge more easily).

Legume forage generally has higher nutritive value in terms of both digestibility and protein level than forage produced by grasses. Also, with legumes, digestibility falls less rapidly with maturity than in warm season perennial grasses.

Plants can also contain unique compounds that have an adverse effect on nutritive value. For example, tannins in most sericea lespedeza varieties reduce digestibility, intake, and animal performance. However, plant breeders have developed low-tannin varieties that result in improved animal performance. Likewise, the development of low-alkaloid varieties has improved animal performance on reed canarygrass.

2. Plant part

Nutritive value varies within the canopy of a given forage species or forage mixture. Leaves are more nutritious than stems, and young leaves are more nutritious than older leaves. Similarly, stems in the upper canopy are more nutritious than lower stems. Young green leaves are more nutritious than dead leaves. Thus, an aim of pasture management should be to keep available forage in a leafy, highly nutritious state throughout the grazing season for higher animal performance.

Some varieties have higher nutritive value as a result of selection for a higher leaf-to-stem ratio. Reducing leaf loss is important in hay harvest, especially with legumes. If hay is handled poorly and many of the leaves shatter, nutritive value will suffer. Diseases or insects that reduce leaf percentage also lower hay quality.

Table 17.1 Seasonal change in in-vitro dry matter digestibility (IVDMD) and crude protein (CP) content of Apollo alfalfa pasture in central Georgia, two-year average. Pastures were sampled at the beginning of each two-week grazing period followed by four weeks of rest in a rotational system.

Month	IVDMD, %	CP, %
April	69	25
May	65	22
June	61	18
July	57	16

Adapted from: C.S. Hoveland, N.S. Hill, R.S. Lowrey, Jr., S.L. Fales, M.E. McCormick, and A.E. Smith. J. Prod. Agric. 1:343-346.

Table 17.2 Seasonal changes in forage tannin concentration of high- and low-tannin sericea varieties at Athens, Georgia, three-year average.

Variety	Tannin content, % d.m.		
	June	August	October
Appalow (high-tannin)	7.9	12.8	10.5
Serala (high-tannin)	8.0	11.6	9.5
AU Donnelly (low-tannin)	4.3	5.3	5.3
AU Lotan (low-tannin)	3.1	4.9	4.6

Adapted from: C.S. Hoveland, W.R. Windham, D.L. Boggs, R.G. Durham, G.V. Calvert, J.F. Newsome, J.W. Dobson, Jr., and M. Owsley. Georgia Agric. Exp. Stn. Res. Bull. 393.

3. Climate

Digestibility of warm season and cool season perennial species is highest in spring, falling to a low level in mid-to-late summer, and increasing in autumn. Even alfalfa under rotational stocking declines in digestibility and crude protein during hot summer weather (**Table 17.1**).

Though drought stress can present danger from nitrates or prussic acid in some situations (see **Chapter 23**), it otherwise has little effect on nutritive value as long as the plants remain alive. Moderate stress may actually increase digestibility. Animal gains on drought-stressed forage are often above average as long as adequate quantities are available.

Excess rainfall may increase the moisture content of forage, having no effect on digestibility. However, with species such as sorghum-sudan hybrids and pearl millet, it may result in reduced dry matter intake and animal performance. Excess rainfall may also reduce protein in grasses as a result of leaching nitrogen from the soil.

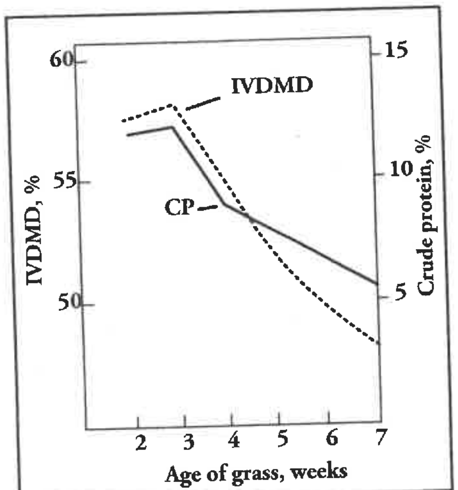


Figure 17.3 IVDMD and CP of Coastal bermudagrass as affected by plant maturity in south Georgia.

Source: W.G. Monson, USDA, Coastal Plain Exp. Stn., Tifton,

High temperature lowers digestibility by increasing lignification. Tannin content of sericea lespedeza also increases with high temperature, reducing intake and digestibility when grazed (**Table 17.2**). Tannin levels decline in sericea lespedeza harvested for hay.

4. Stage of maturity

Maturity usually has a greater effect on nutritive value than does any other factor. As plants mature, cell walls become more lignified and they constitute a larger proportion of the cell, resulting in an overall decrease in digestibility and CP content. This decline in nutritive value with maturity is greater and more rapid in warm season than cool season grasses.

As bermudagrass becomes more mature, yield increases, but digestibility and CP decline substantially (**Figure 17.3**). At seven weeks of age, nutritive value can be very low, with digestibility below 50 percent and CP below 8 percent.

Table 17.3 Changes in Kentucky 31 tall fescue forage CP and IVDMD as affected by stage of maturity at first spring harvest. Athens, Georgia. Three-year average.

Maturity stage	CP, %	IVDMD, %
Pre-bud	19	72
Late boot	16	71
Early bloom	14	66
Seed dough	8	53

Source: C.S. Hoveland and N.S. Hill, University of Georgia.

Cool season perennial grasses such as tall fescue also decline in nutritive value with advancing maturity in spring (**Table 17.3**). While CP remains high until early bloom, it is low at dough stage (see **Appendices A.29** and **A.31**). Tall fescue hay cut at dough stage is just adequate in nutritive value to supply the needs of a dry pregnant beef cow. Well-fertilized aftermath tall fescue harvested in summer can have CP and IVDMD values of 14 and 53 percent, respectively. Autumn-harvested tall fescue is of high nutritive value with CP and IVDMD levels as much as 16 and 65 percent, respectively.

Immature grass may contain 65 percent soluble cell contents and 35 percent cell walls. However, at a mature stage, the same grass species may contain only 40 percent cell contents and 60 percent cell walls, of which 7 percent may be insoluble lignin. Crude protein content may decline from more than 20 percent at an immature stage to only 5 or 6 percent when mature.

Legume species likewise differ in digestibility as they mature. White clover, lacking true stems, maintains its high nutritive value over time. Birdsfoot trefoil stems remain highly digestible as the plants mature. Alfalfa stems become lignified, and digestibility drops sharply after early bloom (**Table 17.4**). Among the annual clovers, arrowleaf stems remain more digestible than crimson as they mature.

Table 17.4 Relationship of the stage of alfalfa maturity at harvest to total digestible nutrients (TDN), CP, and acid-detergent fiber (ADF).

Maturity	TDN,%	CP, %	ADF, %
Pre-bud	65	21.7	28
Bud	62	19.9	31
1/10 bloom	58	17.2	34
½ bloom	56	16.0	38
Full bloom	54	15.0	40
Mature	52	13.6	42

Adapted from: Nutrient requirements of dairy cattle. Nat. Acad. Sci. Publ. 1349.

5. Fertilization

Up to a point, application of nitrogen fertilizer to grasses increases crude protein content, assuming other nutrients are not deficient. However, nitrogen generally has little effect on digestibility of young leaf material. Application of sulfur and calcium to deficient soils may enhance forage digestibility. This can occur because sulfur improves rumen fermentation, and calcium affects plant cell wall composition. Nutrients such as phosphorus, potassium, and magnesium are essential for animals and may need to be added by fertilization or supplementation (see **Appendix A.23**).

6. Diurnal fluctuations

Soluble carbohydrate levels in forage vary, depending on the time of day. These highly digestible carbohydrates accumulate during daylight hours, but much of the accumulated material is used by the plant during the night. Therefore, levels are lowest in the morning and highest after a day of bright sunshine.

Hay cut in the afternoon is somewhat more digestable than morning-cut hay. This may have practical use for improving nutritive value of irrigated hay harvested in dry climates or for haylage and balage in humid areas. However, afternoon harvests may not be advisable in high rainfall areas where every hour of good drying time is needed to cure hay.

7. Other

In humid regions such as the southeastern U.S., rain is a major concern when making hay. Rain during field drying damages legume hay more than grass hay. Also, the drier the hay when rain occurs, the greater the damage. However, delayed harvest due to concern about rain often results in more forage quality loss than does rain damage.

Major losses in nutritive value often occur due to poor storage and feeding techniques (see **Chapter 20**). Producing stored forage with good nutritive value is not enough; good animal performance results when animals actually consume forage that is suitably high in nutrients and low in fiber.

Methods of Measuring Nutritive Value

Laboratory evaluation of forages is an attempt to predict the extent and rate of biological degradation that will occur in the consuming animal. The objective is to be able to formulate diets from compositional information that will result in predictable animal response.

Neutral-detergent fiber (NDF) and acid-detergent fiber (ADF). These methods chemically distinguish the readily available, soluble cell contents from the less digestible cell walls. Neutral-detergent fiber represents all cell wall material, while ADF is a measure of only the lignified or otherwise undigestible portions. Neutral-detergent fiber values are negatively correlated with forage voluntary intake by the animal, while ADF (NDF less the hemicellulose component) is negatively correlated with digestibility (see **Appendices A.29** and **A.41**). Fiber values are often used in equations to calculate energy as total digestible nutrients (TDN).

In-vitro fermentation. In this procedure, forage is digested in rumen fluid, followed by treatment with acid pepsin to simulate the digestive process in the ruminant animal. Results from this procedure give a good approximation of digestibility expressed as in-vitro digestible dry matter (IVDMD - see **Appendix A.41**).

Near infrared reflectance spectroscopy (NIRS). This rapid, reliable instrument technique is based on the amount of light reflected from, or transmitted through, a finely ground forage sample. The desired nutritive value indicators (CP, NDF, ADF, IVDMD) are not measured directly by instrumentation, but rather from prediction equations developed from calibration samples analyzed by traditional chemical methods. This approach is commonly used by laboratories that serve livestock producers. A comparison of the usual forage sample measurements of several important perennial grasses is shown in **Table 17.5**. When comparing grass species, it is important that they be harvested at the same stage of maturity or age.

Table 17.5 TDN, IVDMD, CP, NDF, and ADF of four perennial grasses.*

Grass	Age at harvest, weeks	%				
		TDN	IVDMD	CP	NDF	ADF
Coastal bermudagrass	4	55	62	13	58	29
Coastal bermudagrass	8	49	47	8	65	40
Tall fescue	4	66	63	14	58	31
Orchardgrass	4	66	62	15	58	33
Timothy	4	67	67	13	56	35

[1]Bermudagrass was grown in Georgia, the other grasses in Kentucky. All were harvested as re-growth in summer after an initial spring cutting.
Source: W.R. Windham, USDA Russell Research Center, Athens, Georgia.

Table 17.6 Quality standards for legume, grass, or grass-legume hay.

Quality standard	CP	ADF	NDF	DDM	DMI	RFV
	%					
Prime	>19	<31	<40	>65	>3.0	>151
1	17-19	31-35	40-46	62-65	3.0-2.6	151-125
2	14-16	36-40	47-53	58-61	2.5-2.3	124-103
3	11-13	41-42	54-60	56-57	2.2-2.0	102-87
4	8-10	43-45	61-65	53-55	1.9-1.8	86-75
5	<8	>45	>65	<53	<1.8	<75

% DDM = 88.9-0.779 ADF (% DM).
DMI = 120/forage NDF (% DM).
RFV calculated from (DDM x DMI)/1.29.
Reference hay of 100 RFV contains 41% ADF and 53% NDF.
Source: Hay Market Task Force, American Forage and Grassland Council.

Relative feed value (RFV). In recent years, ADF and NDF values have been useful in developing a relatively simple index to evaluate and compare forages. This index, called the RFV, is a prediction of the rate of intake and energy value of a particular forage. Relative feed value compares or ranks forages according to their digestible dry matter (DDM) and potential dry matter intake (DMI). It is calculated by DDM x DMI divided by a constant. Relative feed value is expressed as percent compared to full bloom alfalfa that has an RFV of 100. The RFV increases as forage nutritive value increases (**Table 17.6**).

Digestible dry matter values used to calculate RFV are a percentage estimate of the portion of a feed or forage that is digestible. This is usually estimated from ADF values, but may be based on animal feeding trials. Different equations are used with ADF values obtained for grasses and legumes, and sometimes for different regions of the U.S.

Dry matter intake values used to calculate RFV are estimates of the relative amount of forage an animal will eat. The DMI may be based on animal feeding trials, but usually is a calculation based on NDF values. As with DDM, different equations are used with different categories of forage.

Relative feed value provides a one-number estimate of the energy value of a forage, haylage, or silage. The RFV of mature (three-fourths bloom to full bloom) alfalfa should be 100. Thus, a forage with an RFV of 125 should have 25 percent more energy than mature alfalfa. Likewise, an RFV of 75 means a forage should have 25 percent less energy than mature alfalfa.

Relative Forage Quality (RFQ). RFQ is another one-number index used to provide a relative ranking of nutritive value within and among various forage species (**Figure 17.4**). The concept is the same, with the primary difference being that RFQ also takes into consideration fiber digestibility, and this is included in the formula used to calculate the number. For forages having similar high levels of fiber digestibility, RFQ and RFV will be the same, or nearly the same, number. However, where fiber digestibility of a given sample is low, the RFQ index will be a lower number, more consistent with the level of animal performance (relative to mature alfalfa) that is likely to occur when the forage is fed. These indices simply represent another way of numerically expressing a comparison of different forages. The same principles known for many years still apply: nutritive value is best when fiber levels are low and digestibility is high. High intake by animals is indicative of high nutritive value. High protein levels are desirable, but protein is not used in calculating either RFV or RFQ.

Both RFV and RFQ are useful predictors of the ability of a forage to supply nutrients to livestock. Neither of these indices is intended to be used for, or feasible to use in, balancing animal diets. Calculated energy (obtained from fiber values) and protein values will continue to be used for that purpose. However, either RFV or RFQ can be of value in pricing hay because each of these indices provides a relative estimate of the feed value (with regard to energy). These indices are normally used to compare lots of hay of the same species, or at least of a similar (for example, two legume hays).

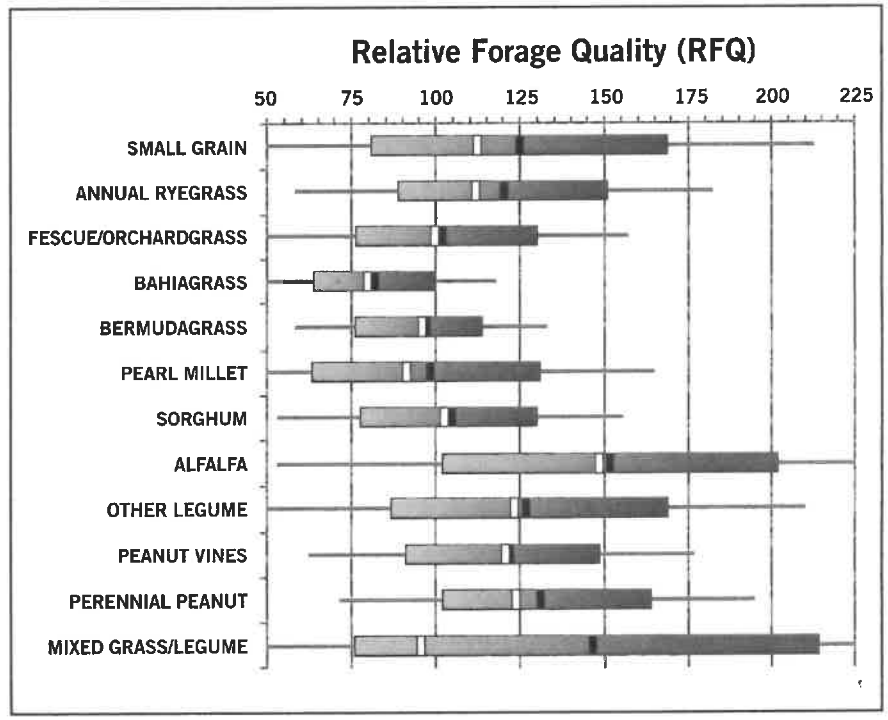


Figure 17.4 The average (black vertical lines), median (white vertical lines), and the extent of what is commonly low or high for a species (extent of horizontal gray lines) for RFQ in samples of various forage species submitted to the UGA Feed and Environmental Water Laboratory from July 2003 – February 2011.

Adapted from: D. Hancock, University of Georgia, Factsheet CS5-F048.

Using Nutritive Value Information

It is not necessary to understand how nutritive value is measured in a laboratory, but some understanding of how nutritive value affects animals is a fundamental requirement for obtaining good animal performance (see **Chapter 18**). A diagram that illustrates feed and forage components is provided in **Appendix A.28.** A livestock producer needs to be aware of the major influences on nutritive value, such as stage of maturity, plant species, and variety influences. It is the total quantity of available nutrients in a given amount of forage, not the total quantity of forage, that is of primary importance in obtaining good animal performance. SF

Nutrient Requirements of Livestock

Ruminants have the unique ability to consume large quantities of forage and convert the fiber components (cellulose and hemicellulose) into useable forms of energy. Energy constitutes the largest and most common performance-limiting nutrient requirement for ruminant livestock and is supplied by pastures, hay, silage, and sometimes grain. The most limiting factor in nutritive value is digestible energy. Digestible energy is generally lower in perennial warm season grasses than in cool season grasses and declines as plants become more mature (see **Chapter 17**).

All animals need a certain amount of protein in their daily diet. Energy requirements, which are more likely to be the primary concern on most livestock farms in the South, are higher for lactating and growing animals than for mature ones. Most essential minerals are adequately supplied in forages. Calcium and phosphorus supplements may be needed when animals are consuming poor hay or grazing frosted warm season perennial grasses in winter.

Nutrient requirements of ruminant animals differ greatly, depending on class of livestock, weight, and desired daily production. The TDN and CP requirements of several livestock classes are illustrated in **Table 18.1.** Forage species differ considerably in their digestibility and suitability as energy sources for different classes of cattle **(Figure 18.1).** For each category of forage species there is a range in digestibility that reflects variations caused by stage of maturity and season of the year. Good pasture management is necessary to keep nutritive value at the upper end of this range for best animal performance.

Table 18.1 Total digestible nutrients (TDN) and crude protein (CP) requirements of selected animal classes.

Animal class	TDN, %	CP, %
Growing beef steer		
450 lb (1.5 lb/day gain)	65	11-13
650 lb (1.7 lb/day gain)	68	10-11
Beef cow		
Lactating	60	10-12
Dry, pregnant	50	7-8
Sheep		
Lamb (finishing)	70	12
Ewe (lactating)	65	13
Ewe (maintenance)	55	9
Fallow deer		
Doe (lactating)	66	14-16
Growing buck	60-64	12-14
Meat-type goat		
Doe (lactating)	62	14
Growing buck	65	14
Horse (maintenance)	70	10-11

Source: M.A. McCann, Virginia Tech University.

Growing Animals

Growing animals such as steers or lambs have high requirements that can be met by small grains, annual ryegrass, or cool season perennial grasses such as orchardgrass, Kentucky bluegrass, and novel endophyte or endophyte-free tall fescue (see

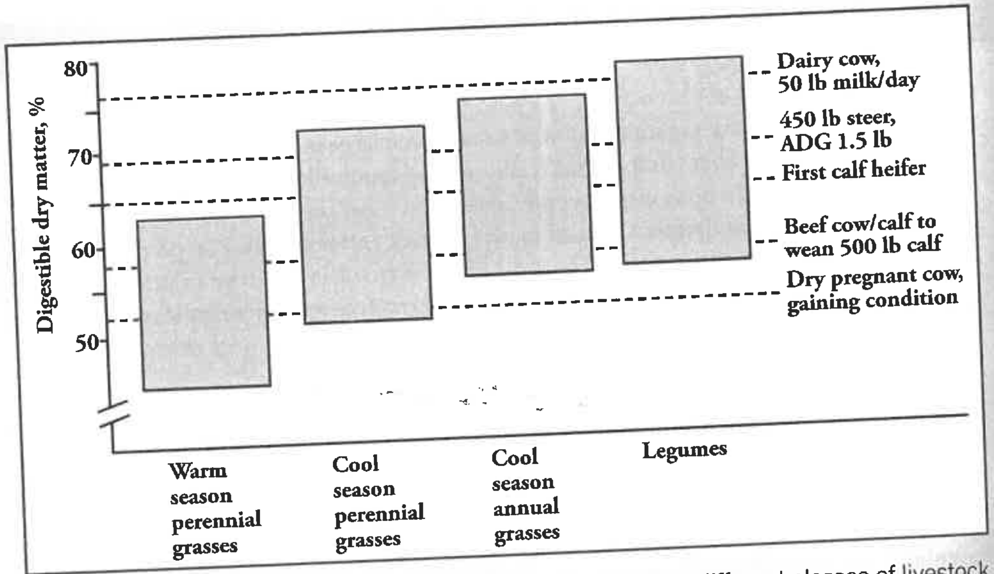


Figure 18.1 Forage digestibility ranges and their suitability for different classes of livestock (ADG = average daily gain).

Adapted from: H. Lippke and M.E. Riewe. Texas Agric. Exp. Stan. Res. Monograph RM6C: 169-206.

Chapter 28). Clovers, alfalfa, or birdsfoot trefoil companion crops can sometimes be used to enhance animal gain on perennial grasses. Warm season perennial grasses such as bahiagrass or bermudagrass lack the nutritive value for high gains and are usually unsatisfactory for profitable grazing of beef steers, lambs, and deer. Warm season perennial grass pastures can provide satisfactory gains for short periods of time in late spring and early summer if closely grazed to maintain a high leaf percentage, but animal performance declines sharply as the season progresses.

Beef Cows and Calves

Most growing pastures of warm season or cool season perennial grasses in the South will adequately supply the needs of a dry beef cow (see **Chapter 27**). However, after killing frosts, the nutritive value of bermudagrass and bahiagrass declines rapidly, especially with heavy rainfall. Protein needs of dry pregnant beef cows are low, but protein supplements must be fed on frosted warm season grass pastures for adequate nutrition. Protein supplementation may also cause cattle to consume more of this type grass and utilize it more efficiently.

After calving, nutrient requirements of beef cows increase markedly for rebreeding and providing milk for calves. Until a calf is about three months old, it is mostly dependent on its mother for food. If calving occurs during January and February when perennial grass pasture growth is very limited, it is important to ... hay (Figure 18.2). Mineral supplements are also necessary at this time.

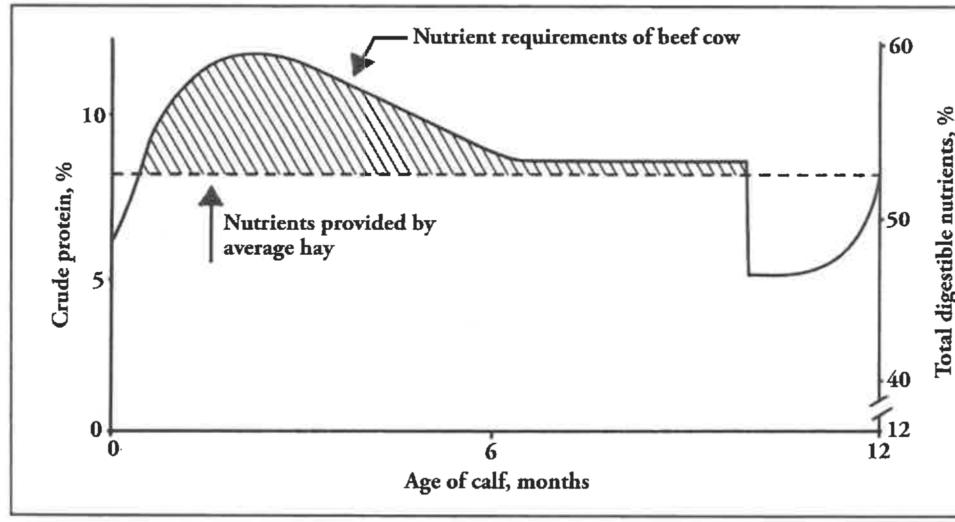


Figure 18.2 Average quality grass hay cannot supply nutrient requirements of a beef cow for rebreeding and providing milk for the calf.

Source: M.A. McCann, Animal Science Dept., Virginia Tech.

Lactating ewes have higher energy and protein requirements than beef cows, so it becomes even more important to have highly nutritious pasture and/or stored feed for good lamb growth.

Winter-born calves begin to consume significant amounts of forage in spring when pasture quantity and nutritive value are high. The nutritive value of pasture forage normally is lower in summer when cow milk production declines and the intake demands of calves are increasing. Overseeding pastures with legumes can improve nutritive value and increase calf weaning weights. Creep feeding of grain to calves on pasture may increase weaning weights, but is only profitable in times of low grain prices and/or high calf prices.

At high stocking rates, creep grazing of beef calves can efficiently increase weaning weights. For autumn-born calves in the lower South, planting cool season annuals on prepared seedbeds and stocking at up to 10 calves per acre has been efficient. For spring-born calves, simply allowing calves creep access to the next pasture ahead of their mothers in a rotational stocking method can efficiently increase weaning weights (see **Chapter 26**).

Replacement Heifers

Replacement heifers require special nutritional consideration. If heifers are bred to calve first as 2-year olds, they should be fed good forage or grain during the first and second winters, similar to that of growing steers. Nutrients must be adequate for continued body growth, development of the fetus as well as the mammary system for feeding the new calf, and rebreeding. Ideally, highly nutritious winter annual or cool season perennial grass pastures can be used to meet the nutrient needs of this class of animal. If grass hay is fed, it will generally need to be supplemented with protein and minerals. It is important that replacement heifers grow adequately but not fatten. Allowing heifers to become fat prior to calving is expensive and may cause calving problems.

Controlled Breeding Season

A controlled breeding season is essential in matching animal nutrient requirements to available pasture forage and reducing supplemental feeding. Generally, this is most easily accomplished with autumn or winter calving in the lower South, winter calving in the mid South, and early spring calving in the upper South. A controlled breeding season generally results in lower calf death losses, heavier weaning weights, and more efficient utilization of labor and resources.

Finishing

Although highly nutritious forage will give good animal performance, grain feeding is needed to achieve maximum liveweight gain. However, since forage is a lower cost source of nutrients, it is usually more profitable to utilize good pasture rather than grain to put on as much muscle and frame as possible. When steers begin to fatten rather than grow (for British breed steers, between 800 and 1,000 lb), their requirements for digestible energy increase and cannot be met by warm season grasses. At this point, grain feeding is needed to achieve adequate finish in a reasonable time.

Grain feeding on highly nutritious annual ryegrass, rye, or wheat pasture is not profitable. Higher stocking rates are possible with grain feeding, but there is little or no increase in individual gains as animals generally substitute grain for good pasture. While steers and heifers can be finished on cool season grass and clover pastures, they are usually only marginally fat and carcass fat is yellow. As a result, they will be discriminated against in price at slaughter. Therefore, it is typical in the U.S. for cattle to be fed on concentrated diets for at least 60 days and usually 120 to 140 days prior to slaughter.

Dairy Cows

Lactating dairy cows require large quantities of highly nutritious feed, including some grain, to achieve optimum production per cow. Consequently, forages, such as alfalfa and corn for silage, are important for high milk production in feedlots. During certain periods of the year, some forages produce enough highly nutritious forage to meet most of the demand for high levels of milk production by feedlot dairy cows. Dairy producers must also utilize stored feed of known nutritive value to provide a diet to maintain lactation at a high level. Good alfalfa hay or haylage and corn silage with grain supplements have been commonly used for dairy

Deer Farming

The fixed breeding season of most deer species means that fawns are born during June, and lactation continues until weaning in September. The nutrient requirements to sustain lactation and provide rapid growth of fawns during this period are high, about double those needed in winter. Highly nutritious alfalfa, clover, or chicory pasture can reduce supplemental grain feeding costs (see **Chapter 31**).

Summary

For efficient and economical production, forage nutritive value must be matched to the nutrient requirements of the class of animal being fed. Grazing beef cows with calves on expensive cool season annual pasture is inefficient unless they are limit-grazed (for example, two or three hours per day for three to seven days per week). Grazing beef steers on poor pasture is unprofitable as it will result in low daily gains even though available forage and stocking rates are high.

Forage nutritive value and quantity of pasture vary greatly during the year. The length of the growing season on adapted forage species differs considerably from the lower to the upper South. The nutritive requirements of animals in each area can be met by utilizing a controlled breeding season to match the nutritive value and quantity of forage, supplemental feeding, and utilizing pasture legumes whenever feasible. SF on when forage nutritive value begins to decline. Light-weight steers, initially ghing 400 to 500 lb, are best suited for stockering as weight gains are high and e calves can be grazed on a given area of land. In some situations, stocker animals be finished on pasture and slaughtered at about 1,000 lb for lean beef.

mmary

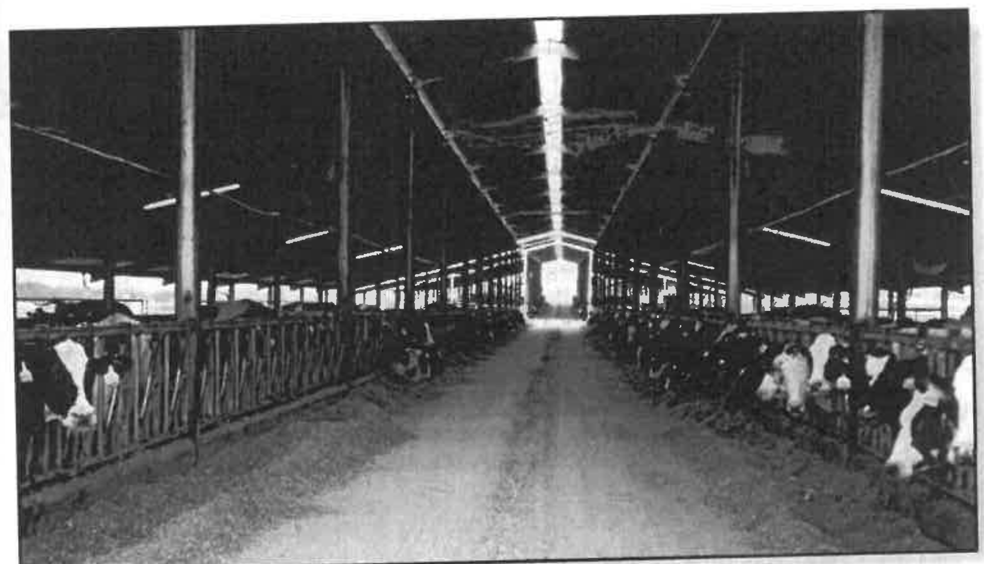
Stockering offers excellent opportunities for profit when operations are well aged. Several pasture systems are available in each climatic zone of the South. vever, good pasture management is essential to maintain high forage nutritive e throughout the season. Adjustment of stocking rate, supplemental feeding, and d health care are necessary to achieve the high gains needed for profitability. SF

The U.S. is the world's largest milk producer. Though dairy cow numbers have declined in recent decades, milk production has increased. This is a result of higher milk production per cow, which has been driven by better genetics, nutrition, and management. Fluid milk consumption per capita has declined along with a shift to low-fat and skim milk. In contrast, cheese consumption has soared over several decades with the popularity of Italian and Mexican foods. Since 2000, overall cheese consumption is up 20% as a wider range of cheeses are marketed. Yogurt consumption has also shown spectacular growth as sales of this product are up over 55% since 2000. The dairy industry remains important.

Dairy cow numbers in the southern U.S. are relatively small compared to the Upper Midwest, Northeast, and California. Cow numbers have declined in nearly all the southern states over the past decade. However, this decline appears to have slowed and a number of large pasture-based dairies have been started in recent years.

Confined Feeding Systems

Until the 1950's, U.S. dairy farms were overwhelmingly small, family-operated units where pastures provided over 30% of the nutrients consumed by dairy cows. In the northern U.S., dairy cattle were normally grazed from spring until autumn after which they were fed in confinement. In the southern U.S., winter annuals were grazed during winter and spring to reduce silage or hay feeding. In the 1950's, small dairy farmers faced financial problems as they had to install refrigerated bulk milk coolers and other equipment while facing lower milk prices. Many farmers quit while others bought more land and cows and switched to year-around confined



Cows at feed troughs at confined feeding dairy farm with 1,000 cows in southern Georgia.

feeding to increase milk production. Confined feeding systems, where cows are kept inside nearly year-around, provide dairy cows with a uniform supply of nutrients from silage, hay, and concentrates throughout their lactation. This contrasts with conventionally-managed pastures where forage nutritive value and quantity often vary greatly, depending on temperature, soil moisture, and plant maturity.

During this period, the dairy industry largely moved to confined feeding systems in all parts of the U.S. Milk production per cow in these larger units rose, but profits were squeezed from high investment costs in more land, cows, and equipment, leading to increased debt. This system tested the management skills of a farmer. Well-managed farms show that confined feeding systems can be highly efficient and profitable dairy cow enterprises.

High-Energy, Nutritious Forage is Necessary for Success

High producing dairy cows require adequate levels of energy, protein, vitamins, minerals, and water in their diet. Energy and protein are of major importance because of the amounts required and the expense of providing them. Feed cost is about 60% of the cost of milk production. Highly nutritious forages are the most economical source of the essential nutrients.

For optimum economical production, dairy cows must consume large quantities of nutrient-rich feed. A highly nutritious forage is one that results in high intake (is consumed in large amounts), is highly digestible (capable of supplying large amounts of nutrients), and contains the proper balance of needed nutrients. Nutritional value can make the difference between high or low production and between profit and loss in dairy feeding programs.

Feeding forage with high nutritive value reduces feed cost, stimulates high milk production, increases dry matter intake, may extend the productive life of the cow, and improves health and thriftiness. Conversely, feeding forage with low nutritive value can be costly by reducing feed intake and milk production.

Energy. Although corn and other grains supply energy in dairy feeding programs, high-energy grain crops harvested and stored as silage provide the major energy source for most dairy operations in the South (see **Chapter 21**). Corn is rightly considered king of the silage crops. It has the potential of producing more digestible energy per acre than other crops.

In addition to corn, other crops commonly used for silage are sorghum, pearl millet and small grains. These crops produce good yields, are easily mechanized from standing crop to feeding, and are dependable if irrigated or grown in climates where there is ample rainfall.

Many factors influence silage yield and feed value including: rainfall, variety, fertility, cultural practices, pests, stage of maturity at harvest, and harvesting and storing conditions. In much of the Lower South, irrigation is essential for dependable production of corn silage with high grain content. Corn and sorghum have the ability to produce large amounts of energy and nutrients per acre, but crude protein must be supplemented for high milk production.

Protein. Protein is needed for growth, production, reproduction, and maintenance. The amount required in the diet depends on animal size, condition, growth rate, and level of production. Protein content of forage crops varies considerably, depending on many factors, especially plant species and stage of maturity. In general, legumes are higher in protein than grasses.

Legumes harvested at bud to early bloom and grasses harvested at boot stage for first harvest and at a leafy stage for aftermath harvest are usually high in protein (see **Appendices A.29** and **A.31**). On dairy farms, alfalfa or an alfalfa-grass mixture is an excellent complement to corn silage. In the Southern U.S., winter annual grasses are increasingly grown for hay or silage for dairy cows. These cool season grasses are highly digestible and high in crude protein. Other forages such as red clover grown in association with orchardgrass, novel endophyte tall fescue, or timothy can provide excellent dairy hay when harvested at the proper stage of maturity. Other cool-season species as well as warm-season species and various by-products can also be used in formulating dairy rations.

Forage Testing. In order to adequately and economically provide a balanced ration to the dairy cow, it is important to know the nutrient content of feed sources to be used. With the wide variety of on- and off-farm feed sources available throughout the South and the importance of forage nutritive value to the dairy herd, forage testing is essential. Advances in analytical techniques (e.g. near-infrared spectroscopy) have reduced costs of these analyses.

Forage testing provides the framework for ration balancing. Feed sources should be sampled so that representative samples can be submitted for analysis. The sampling process is critically important, as only a few grams of material submitted for analysis may represent many tons of feed or forage. Results from the analyses can then be used to provide a balanced ration without the extra cost of unnecessary supplements.

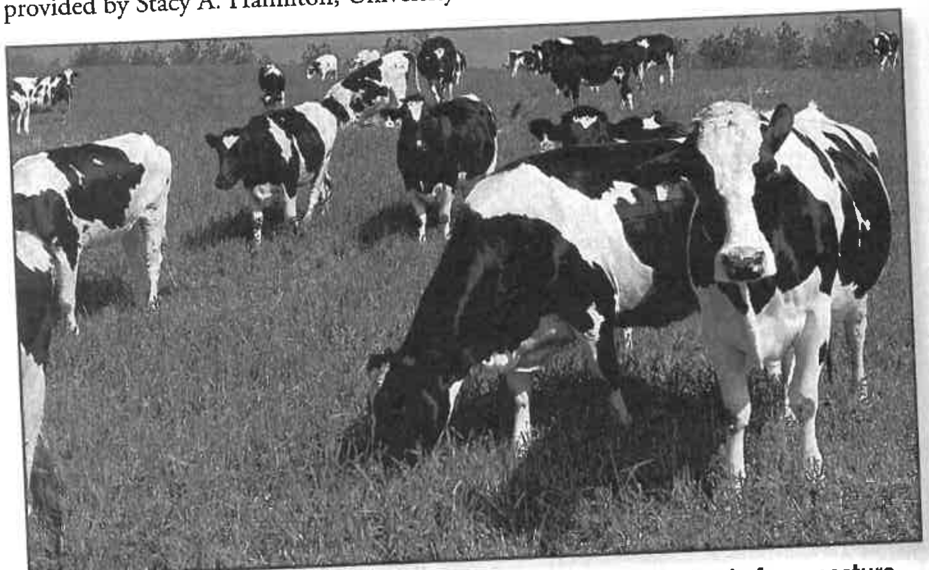
Pasture-Based Dairies

Even with the success of confined feeding as the norm for most U.S. dairy cows, milk production cost is considerably higher than situations where emphasis is placed on well-managed pastures that provide adequate amount of nutritious forage over the growing season. New Zealand dairy producers have mastered these grazing principles better than most. New Zealand, the world's largest exporter of dairy products, has historically been the world's lowest-cost dairy-producing region. One factor is a cool, moist climate without temperature extremes that permit nearly year around grazing. However, a factor often overlooked by most in the U.S. is that the New Zealand dairy farmer manages pasture as an excellent crop. The grazing milk cow is managed as a harvesting machine to maintain highly nutritious pasture forage over the season. Grazing management is both a science and an art that is taken seriously there, but has been largely ignored in the U.S. As a result, in New Zealand

and other regions with similar grassland management, input costs are much lower than for U.S. dairy producers.

Over time, adventurous dairy farmers on smaller farms in various parts of the U.S. copied this strategy of intensively managing pastures. A substantial number of smaller dairy farmers in northern states such as New York, Pennsylvania, and Wisconsin (with a long winter feeding period) have been successful with seasonal grazing. Even with a long winter feeding period of six to seven months, they claim grazing is more profitable. Research on this is limited, but generally supports these claims. In a large dairy farming area of southwest Missouri with a longer growing season, about one-third of the dairies utilize pasture. These dairies usually have between 100 and 150 cows each.

Cattle graze a range of forages: winter annuals, perennials such as orchardgrass, perennial ryegrass, novel endophyte tall fescue, and white clover. Some summer annuals are also grazed, including crabgrass, pearl millet, and sudangrass. A grain supplement is fed in the milking parlor, but generally no additional stored feed, except in winter. Irrigation is limited but increasing. Rotational grazing systems use 30 to 40 paddocks with cattle rotated twice daily to new paddocks. (Information provided by Stacy A. Hamilton, University of Missouri Dairy Specialist).

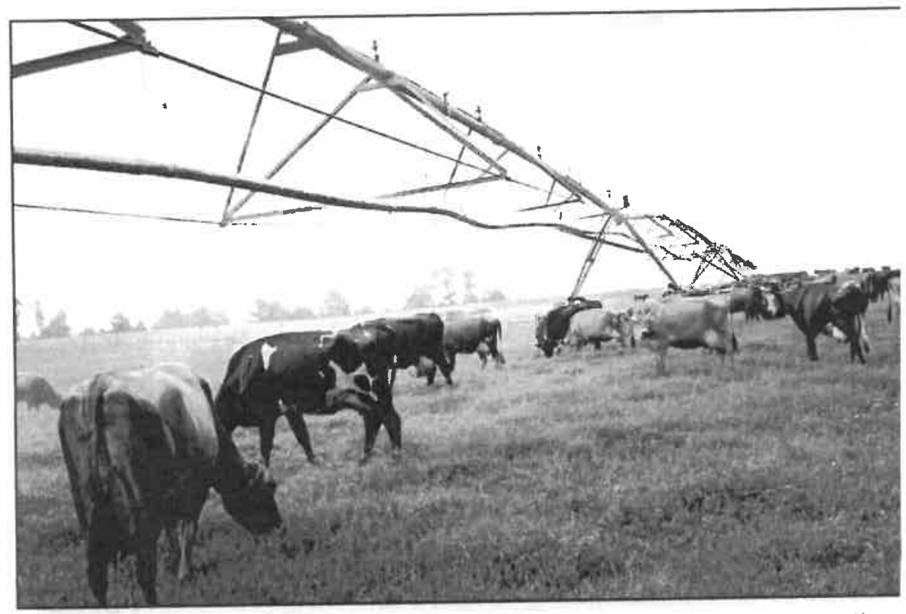


The number of dairies providing most of the nutrition for animals from pasture forage is increasing.

Pasture-Based Dairies in the Lower South

In the Lower South, the smaller dairy units that generally utilized winter annual pastures have largely disappeared, replaced by much larger confined feeding dairy farms, ranging in size from 400 to 2,000 or more cows. A small but growing number of pasture-based dairies are scattered around the South from Virginia to northern Florida. In recent years, large year-around irrigated pasture-based dairies have become a major agricultural enterprise in southern and eastern Georgia. The first such operation, a 500 cow unit, was started by a husband and wife near Quitman in southern Georgia in 1993. It was highly successful and today they have 1,500 cows on three farms plus a gourmet cheese factory and a new yogurt plant. Their success and high profitability was largely ignored until 2007 when two New Zealand investment groups developed more pasture-based dairies in eastern Georgia. Since then, additional large pasture-based dairies have been established and now they constitute over 20% of the dairy cows in the state.

What accounts for this rapid growth in pasture-based dairies? It is a highly profitable enterprise with input costs much lower than confined feeding dairies. Mild winter temperatures generally permit year around grazing. Flat Coastal Plain sandy loam soils in southern and eastern Georgia are underlain by a dependable aquifer recharged with water from the mountains. This supplies abundant irrigation water from a shallow depth. This enormous area extends into southeast Alabama, northern Florida, and coastal South Carolina and North Carolina. Investors continue to purchase large peanut and cotton farms equipped with center pivot irrigation facilities for development into 400 to 800 cow pasture-based dairies. Irrigation is critical to provide dependable amounts of highly nutritious pasture forage in this region of unreliable rainfall. Pasture-based dairying is possible outside this aquifer area in the Lower and Upper South, provided irrigation water is available from rivers or lakes. Center pivot irrigation systems provide a means of mitigating heat stress on cattle during the hot summer period. Mister systems on the center pivot irrigation frame are positioned to cool the cows as they graze each paddock.



Dairy cows under mister grazing Tifton 85 bermudagrass-white clover in southern Georgia.

Dairy cows on rotationally grazed rye-ryegrass paddocks in southern Georgia.

In the Deep South, the pasture base is usually Tifton 85 bermudagrass, which produces more highly digestable forage than other bermudagrass varieties. Winter annuals (cereal rye or annual ryegrass) are overseeded in autumn for winter grazing. Some producers use pearl millet or crabgrass for summer grazing. White or crimson clover may also be included. Farther north, either novel endophyte tall fescue or orchardgrass, with red clover or white clover, are good options.

Dairy cows on pasture-based dairy farms will produce substantially less milk per cow than those in confined feeding systems. The highly productive Holstein cow used in confined feeding is unsuitable for a grazing system in the Lower South. The most desirable dairy cow for this purpose is a Jersey or Jersey cross. This small-framed animal has better heat dissipation, lower nutrient requirements for maintenance, good grazing ability, and adequate milk production. A grain supplement is fed in the milking parlor, but generally no additional stored feed is provided except as needed during low pasture periods in winter. However, some of these grazing dairies feed corn silage to maintain a higher level of milk production during certain periods. In the mid-South, such as in southwest Missouri, winter feeding of stored forage is essential.

Paddocks

The main objective in a grazing system is to maintain forage at peak nutritive value over as much of the season as possible. The pasture area covered by the center pivot irrigation system is subdivided into multiple paddocks of approximately five to eight acres each. Fence lines surrounding the paddocks consist of electrified high tensile smooth wire, which is amenable to temporary electric polywire cross-fencing. Thus, the paddocks are flexible from the standpoint of controlling areas where livestock can graze. Each paddock has a centrally located water supply positioned so cows have access to water regardless of where cross-fencing is placed in the paddock.

Managing and utilizing the forage requires knowledge of pasture productivity, expected consumption by the cows, and how much land area must be dedicated to the herd in order to provide sufficient forage for their dietary needs. Typically, cows are rotated from one paddock to the next every 12 hours after milking. Quantifying the amount of forage in the paddocks is easily done with rising plate meters (see **Chapter 26**).

Pasture Nutrients

Conventional confined feeding dairy systems often have problems with excess accumulated nutrients imported to the farm. They often have limited land areas on which solid and liquid waste can be distributed so accumulated nitrates and phosphorus may have adverse environmental consequences. In contrast, research on pasture-based dairy systems show relatively uniform distribution of feces and urine by the animals. The small amount of animal waste from milking parlors (25%) occurs at a low rate. Conversion of organic nitrogen associated with urine and feces into nitrates is at a rate that permits efficient use of the converted nitrogen by pasture plants. Generally, groundwater nitrate levels are low. Likewise, phosphorus accumulates at a slow rate in pasture systems. Another benefit in perennial pasture systems is that soil organic matter increases at a rapid rate, improving the water-holding and nutrient-holding capacity, an example being a Georgia study in which soil organic carbon level and average animal carbon increases were documented (**Table 29.1**). Over time, these pasture systems appear to require less nitrogen fertilization. This is a result of improved soil health and nitrogen mineralization rates that more closely approximate the demand by pasture plants.

Advantages

It would appear that intensive pasture-based systems offer some important advantages over confined feeding systems in the South. Major savings are a result of reduced infrastructure and much lower investment in equipment and fuel for

Table 29.1 Average soil organic carbon content in three paddocks located on a pasture-based dairy (Wrens, GA) one and three years after established into permanent pasture.

	% Soil organic C		Average annual carbon increase, lb/A
Sampling depth	Year 1	Year 2	
0-15 cm	0.785	1.237	3,013

Source: N.S. Hill, Unpublished data.

forage growing, harvesting, and feeding of stored silage and hay. Labor costs are generally lower. Waste disposal costs are mostly eliminated. Cows are less stressed and can be maintained over more lactations, reducing costs for replacement heifers. Cattle on pasture also are less likely to have mastitis and there is a lower incidence of foot problems.

Summary

Confined feeding systems are the norm for most U.S. dairy producers. They are highly efficient when well managed. Milk production per cow is high, but investment costs are also high, so excellent management is required to make them profitable. Feed cost represents the largest single expense a dairy producer faces. Nutritious forages are the most economical sources of the essential nutrients needed by dairy cows. Forage testing is essential to efficiently and economically balance rations with off-farm feeds, including by-products from industry.

The high inputs and production costs of confined feeding dairies compare unfavorably with pasture-based dairies that utilize efficient grazing principles. As a result, pasture-based dairies are used to some extent in all areas of the U.S. in an effort to reduce costs of milk production. The potential for such dairies that use irrigation appears especially bright in the southern U.S. where the need for stored forage is much less. Some areas offer the opportunity for year-around grazing, greatly reducing investment in equipment, fuel, and labor needed in a confined feeding system. Even with lower milk production per cow, large pasture-based dairies offer opportunity for greater profitability. SF

Forages for Horses

There are several reasons why horse owners should have some knowledge of forage crops. Horses need forage in their diet because it helps prevent digestive problems. An adequate quantity of nutritious forage is also an economical way to minimize feed costs, which normally constitute the greatest expense involved in keeping horses.

In addition, knowledge of certain potential problems that may occur in pasture situations or that can result from feeding an inappropriate type of hay or grazing certain types of plants may enable an owner to avoid injury or death to animals. Horses are also less likely to chew on wood or other objects when in a good pasture. And finally, pastures provide a healthful exercise area for horses while beautifying the landscape.

General Nutritional and Feeding Information

Horses are natural forage eaters as evidenced by the fact that wild horses do quite well in open range situations. Feeding of concentrates becomes necessary only when there are great demands on the animals, such as when they are being worked or when young and growing. The late gestation and lactation periods also require concentrate supplementation to meet nutrient needs. At other times, good pastures can totally meet nutrient requirements. If only poor forage is available, supplemental feeding may be necessary, especially for young, growing animals or lactating mares.

Pastures such as this Kentucky bluegrass/white clover mixture in central Kentucky provide an exercise area and good nutrition while beautifying the landscape.

Horses are not ruminants. Their digestive system differs considerably from those of cattle and sheep. Instead of having four stomachs, including a large rumen where fermentation and microbial digestion take place, horses have a single, relatively small stomach. However, they do have a well developed cecum just beyond the smaller intestine in which bacteria digest forage somewhat like the rumen of a cow, although less efficiently (see **Figure 17.2**).

The low digestion efficiency in the cecum results in a greater requirement for high quality protein. Much of the protein obtained by cows and sheep is produced by bacteria in the rumen and subsequently digested in the ruminant's true stomach, or abomasum. Since the horse digests forage after materials pass through the true stomach and small intestines where many nutrients are absorbed, less of the protein synthesized in the cecum is available for absorption.

Because of the small stomach size and characteristics of their digestive system, horses need to be fed frequently. Furthermore, they need to consume highly nutritious hay or pasture that will be easily digested and move rapidly through their digestive systems. How a horse is fed will greatly influence its growth, reproduction, speed and/or strength, as well as its appearance. As with any type of animal, the nutritional needs of horses vary depending on size, age, and activity. Diets should be formulated by qualified individuals based on the class of animal and the specific nutrient analyses of materials being fed.

The diets of horses can consist of a combination of pasture, hay, concentrates, and even well-ensiled silage made from corn or small grains (though silage should not comprise more than about 50 percent of the roughage intake). Once a diet has been formulated, abrupt shifts in feedstuffs should be avoided, especially from very low quality to very high quality. Gradual changes are much less likely to cause digestive upsets or colic.

Hay for Horses

Hay is an important feed for horses, and both the nutritive value and the amount fed should receive careful consideration. Non-lactating broodmares and idle mature horses can do well on highly nutritious hay alone, while increased activity and reproduction require supplemental feeding. Even when other supplemental feed is being provided, it is desirable to furnish horses with hay because it tends to prevent colic and digestive problems. Horses need to receive about 1 to 2 lb of highly nutritious hay per day per 100 lb of body weight.

Many types of forage can make good horse hay. Legume hays that are often fed in the South include alfalfa, sericea lespedeza, and red clover. Second cutting red clover hay can cause excessive slobbering due to a mold that sometimes is present, but this is mainly a cosmetic problem and normally not dangerous. When red clover is cut at the early bloom stage rather than being allowed to become quite mature, the mold normally does not have time to make any significant growth.

In the lower South, bermudagrass or bahiagrass make good summer pastures f horses.

Among grass hays, timothy has the reputation of being especially good for horses, but other types of grass hay can be equally acceptable. Bermudagrass, ryegrass, and/or small grains, and either endophyte-free or novel endophyte tall fescue all have the potential to make excellent horse hay if harvested at the proper stage of maturity and not damaged by rain.

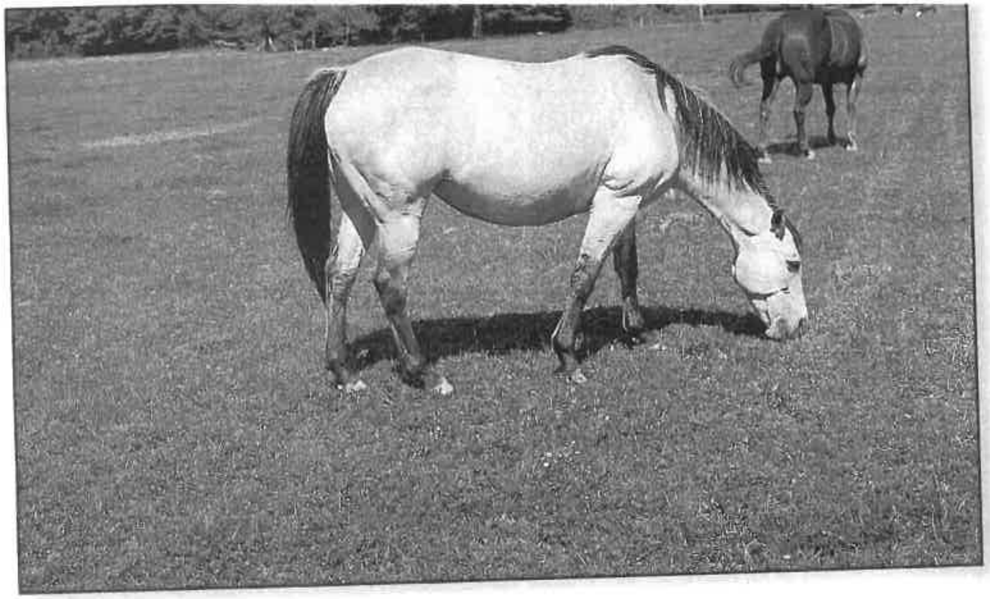
Hay and other feed materials should be free of mold; otherwise, digestion m be upset. Dry, dusty hay can also irritate the lungs, resulting in a cough, runny eye or nose, and possibly pneumonia or an incurable condition called heaves. Good horse hay should be free of weeds and foreign objects. Hay should also be leafy an have a pleasant aroma. Fine-stemmed, soft hay is preferable to coarse, fibrous hay.

A misconception is that good hay will always be a bright green color. Althou a bright color is an indication of no rain damage, color alone is an inadequate way to evaluate hay because poor hay can have bright color while excellent hay will eventually lose color with time. Hay color makes no difference to horses.

When purchasing hay, it is best to buy it by the ton if possible because it is considerably cheaper when bought in quantity. Also, when purchased by the ton, one does not have to be concerned with variability in bale size, which greatly affec the cost of hay purchased by the bale.

Although visual inspection is quite useful, the best way to evaluate hay nutriti value is by a laboratory analysis. Many reputable hay dealers have their hay tested as routine practice. Beware of dealers who do not want an analysis of their hay.

Hay belly is a term that some horse producers use to refer to animals having large, distended digestive tract. This occurs as a result of feeding large quantities of highly fibrous forage. Good hay does not cause this problem.



Winter annuals make excellent horse pastures.

Pasture for Horses

Providing pastures for horses is a healthful way to allow them to get exercise while simultaneously furnishing the nutrients they need. The amount of pasture required for a horse will vary depending on factors such as size and age of the horse, pasture species, amount of supplemental feed provided, and soil fertility. However, for most of the South, at least 1.5 to 2 acres of pasture should be provided for each mature animal. Generally a horse will consume about 2 percent of its body weight in dry matter per day.

Mature, non-working horses and well-developed older yearlings can normally be maintained on good pasture with little or no grain supplementation, but should have salt available. Animals with higher nutritional requirements, such as young growing horses or work horses, may need some grain and good hay along with pasture, especially at times of the year when forage availability is limited.

Many different forage plants can be used for pasture in the South, and most make suitable pastures for horses. While horses will consume some forage of most legumes, they generally prefer grasses. In most cases, pastures should consist of grasses or of grass/legume mixtures. However, arrowleaf clover and vetch are two annual legumes that are quite unpalatable to horses.

Bermudagrass, bahiagrass, and dallisgrass are often used to pasture horses in the lower South. In the upper South, Kentucky bluegrass and orchardgrass are commonly used for horse pastures. In addition, endophyte-free or novel endophyte (see **Chapter 25**) tall fescue makes an excellent horse pasture, but in the interest of long-term persistence, care should be taken to avoid overgrazing. As discussed elsewhere in this book, white clover, red clover, or birdsfoot trefoil can be used as companion species with these cool season grasses. Alfalfa can also provide excellent grazing for horses.

Winter annual grasses (small grain and/or ryegrass) or winter annual grass/legume mixtures make superb horse pastures. These can either be planted on a prepared seedbed or overseeded (or sodseeded) on a warm season perennial grass. Suitable summer annuals include pearl millet, browntop millet, and crabgrass. With management to allow reseeding, crabgrass can be a dependable volunteer species following winter annuals planted in autumn on a tilled seedbed.

Browntop millet makes a good quality, but short-lived pasture. Pearl millet is much more productive, but may be initially unpalatable to the animals. Due to its erratic growth, pearl millet is also difficult to keep stocked properly.

Mares often have reproductive problem toxic endophyte-infected tall fescue, but toxic (endophyte-free or novel endophyte fescue pasture or hay is excellent for hc

Species to Avoid

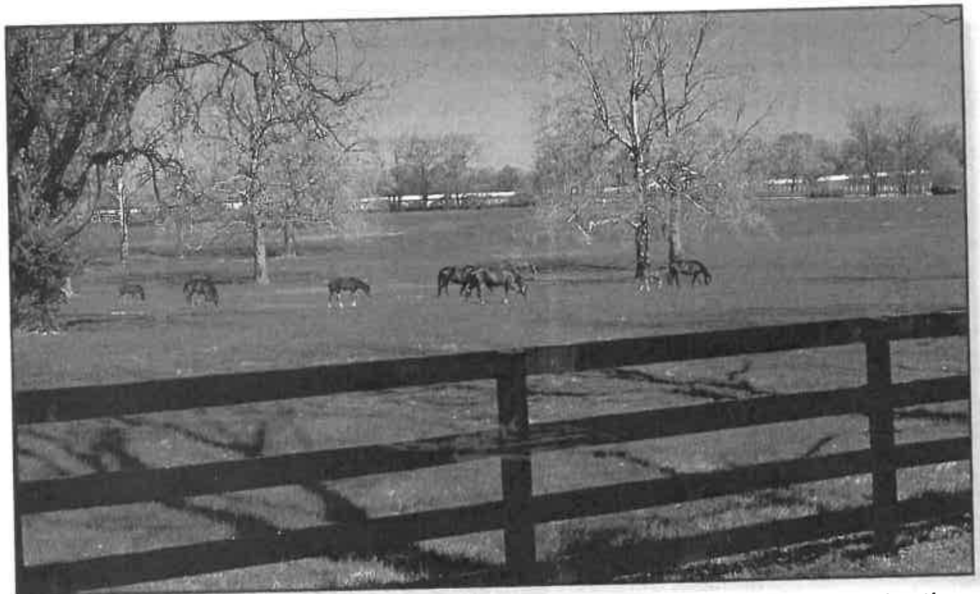
Sorghum, sudangrass, johnsongrass, and particularly sorghum-sudangrass hybrids are not recommended for horse pastures. Horses grazing these species may develop cystitis, which results in paralysis and urinary disorders. Hay of these species is safe to feed. German or foxtail millet is also not recommended (see **Chapter 5**).

Toxic endophyte-infected tall fescue should not be used as pasture for pregnant broodmares, especially during the last three months of gestation (see **Chapter 25**). It has also been shown to reduce weight gains of yearling horses and may have other effects that have not been documented. Non-toxic (endophyte-free or novel endophyte) tall fescue are excellent, but the latter has much better grazing tolerance and stand persistence in horse pastures.

Special Pasture Management Considerations

It is not unusual to see horse pastures that are overgrazed, trampled, and unproductive. While a basic problem is often inadequate pasture area, lack of grazing management is also a problem in many cases, even when adequate pasture forage is available.

Horses are more selective than cattle and tend to spot graze. In addition, they bite off forage very closely. The result is that, without proper management,



Kentucky bluegrass is a commonly-used forage in horse pastures in the upper South.

some areas in a pasture are heavily grazed while others are left virtually untouched. If this situation is allowed to continue too long, close defoliation may hurt plant vigor and even forage stands in the grazed spots, while much forage is wasted in ungrazed areas.

Periodically moving animals from one area to another can provide the following benefits: 1) increase the vigor of pasture plants by resting them on a regular basis; 2) achieve more even utilization of the forage produced; 3) minimize hoof damage; and 4) reduce parasite problems. Electric fencing, either high tensile wire or electrified tape, is safe and works well with horses, though it is best to condition them by initially providing exposure to only a short strand of electrified wire.

After removing horses from a pasture area, it may be desirable to clip the remaining forage to even out the overgrazed and undergrazed areas and to keep forage plants young and tender. Cattle can also be used to graze down an uneven pasture after horses have been removed. Dragging pastures after horses have been moved scatters dung and, with the possible exception of dragging done in spring, reduces parasite problems.

If pastures are overstocked, horses will not have the opportunity to selectively graze, and nutritional value of forage will drop. Grazing horses and cattle together is desirable because cattle reduce the effects of spot grazing. Also, horses and cattle will graze around each other's fecal and urine spots, but not their own.

Pastures for horses should be well drained, free of holes or stumps that might cause injury to the animals, and contain no poisonous plants (see **Chapter 24**). It is important to have safe fences that will not easily injure the horses. Fertilization should be according to soil test recommendations. There is no need to remove horses from pastures during routine fertilization unless the equipment frightens them. However, if a fertilizer spill should occur, it should be immediately cleaned up. Horses need access to shade, plenty of clean fresh water, salt, and a basic mineral mixture. To reduce parasite exposure for yearlings, it is desirable to graze mature horses separately. Horses do not normally bloat on pasture, but may founder on an extremely lush pasture if they are not acclimated to it and are allowed to overeat.

Spraying of horse pastures with an appropriate herbicide to control weeds is highly desirable when weeds are a problem. Any grazing restrictions provided on the herbicide label should be strictly observed.

The hooves of horses can be more damaging to pasture than those of cattle. This is another reason why rotational stocking is desirable, particularly in newly established pastures. Any type of pasture can be damaged if overstocked, but bermudagrass and bahiagrass are more tolerant of treading than most species. Tall fescue is also reasonably tolerant. Pastures recently planted on a prepared seedbed are especially vulnerable and should be protected until a good root system has developed. It may also be necessary to protect even a well-established pasture by temporarily removing the animals during wet periods when the ground is soft. SF